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Qualcomm

C-band Flexible Use UE OOBE Proposals: Exclusion Zones associated with certain OOBE levels and Use of Network Signaling

Qualcomm Incorporated

Agenda

- Background and C-Band mobile UE OOBE options
- Review interference scenario and assess risk
- C-band FSS earth station interference protection criteria
- Exclusion zone and interference statistics simulation results
- Backoff required to meet mid-range OOBE mask
- Conclusions and Proposed Path Forward

Background

- Qualcomm has shown that substantial UE power back-off is required to meet the current CBRS emissions levels that apply above 3.7 GHz were the FCC to impose those same levels above the new C Band flexible use band
- The FCC need not impose the CBRS OOBE levels above the new C Band flexible use band
  - FCC record reflects improved FSS receiver filter performance.[1] CBA, for example, "has worked closely with filter manufacturers for over 12 months to develop a 5G rejection filter that provides performance well beyond that specified in the FCC's [CBRS] rules." CBA Reply Comments (Aug 14, 2019) at 17-18.
  - Relaxed OOBE levels (from CBRS rules) ensures robust 5G service in the new C Band spectrum, while also providing adequate protection from harmful interference for FSS receivers

1. Enables coexistence by effectively reducing the blocking risk to FSS receivers leaving only a very limited interference risk from OOBE as addressed herein.

C Band Mobile UE OOBE options

1. **-13 dBm/MHz**, with dynamic null-steering for interference mitigation based on measurements taken at each FSS station. See Verizon, CBA Comments.

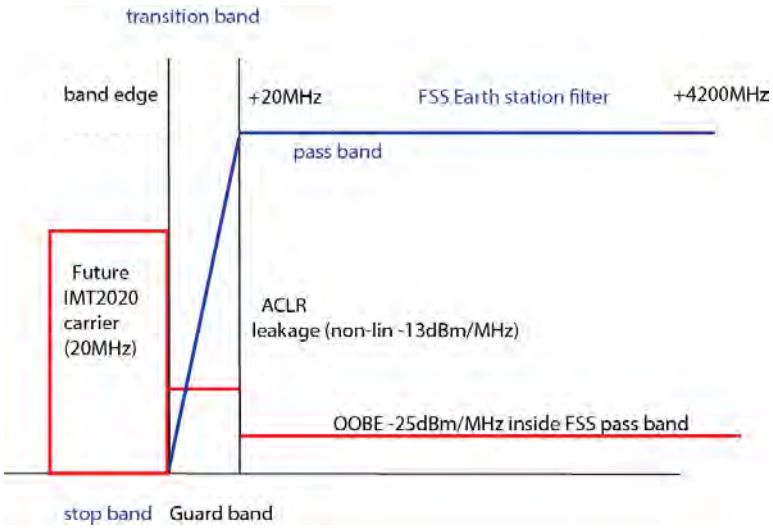
2. Mid-range option : **-13 dBm/MHz from edge to 20 MHz, - 25 dBm/MHz beyond 20 MHz**, coupled with BS site coordination;
   - provides a short-term, low probability of interference from UE to FSS receivers, due to small contours (as detailed herein); can couple with 24/7 interference hotline as in Option 1

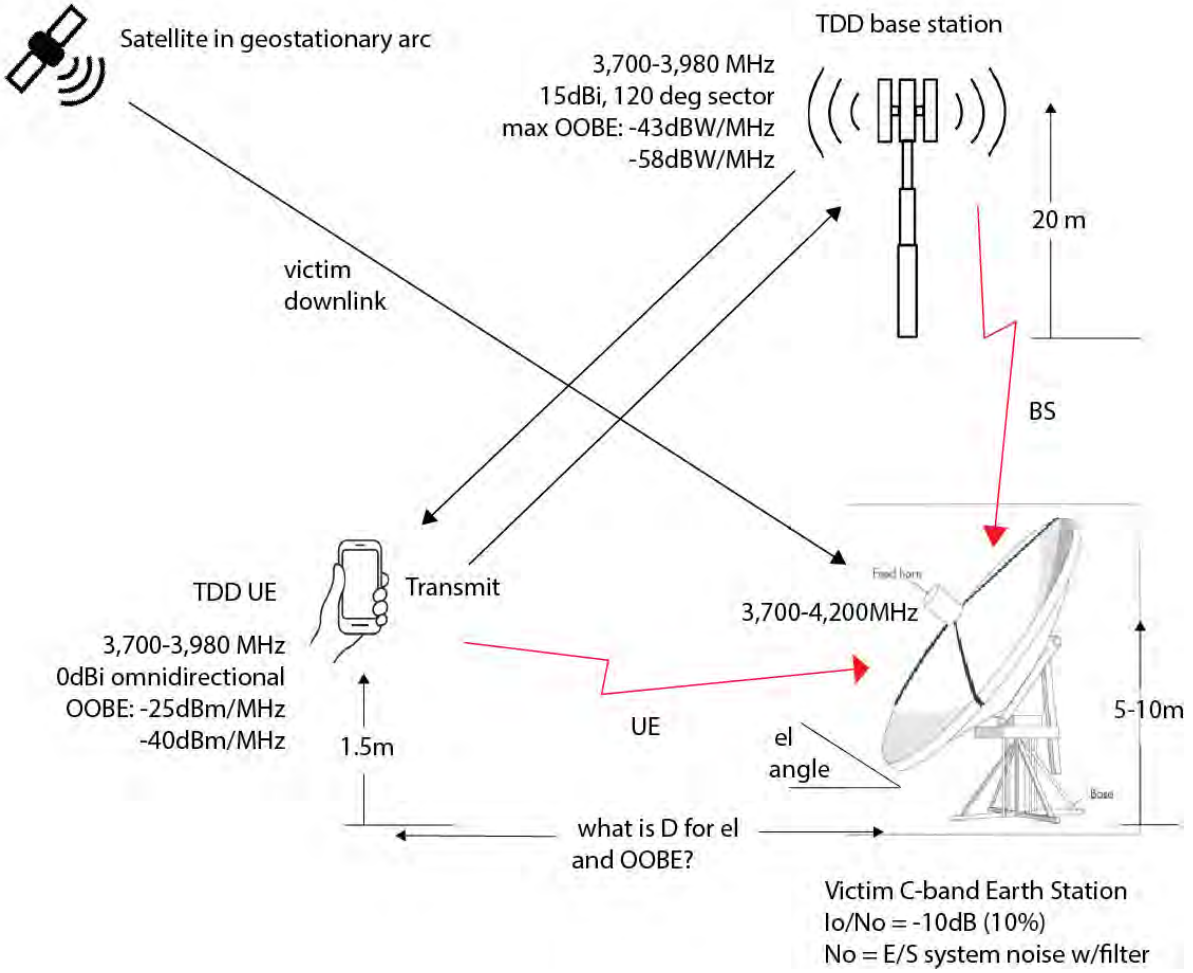
3. Preferred Mid-range OOBE option: **- 13 dBm/MHz from edge to 20 MHz, -25 dBm/MHz beyond 20 MHz** where UE is communicating with a BS within 1 km of an FSS receiver, and **-13 dBm/MHz elsewhere**
   - Controlled via network signaling from the BS

Qualcomm believes mobile devices could use 3GPP Band n77 under each of these options, assuming no other unique rules

Adjacent Channel Interference scenario

Earth station filter needed to prevent LNA(B) overload provides 20 MHz guard band





Interference protection criteria

1. Long-term,100% of time

I_0/N_0 = -10 dB ($\Delta T/T$ = 10%) at HP reference filter O/P (A=1 dB) prior to LNB

$T_{sys} = T_{antenna} \cdot A_{filter} + T_{filter} + T_{lnb} = 179k$

$= 55k/1.26 + 290.(10^{1dB/10} -1) + 60k$

$N_o = KT = 10 \cdot \log(179k) - 228.6 = -206.07$ dBW/Hz

allowable $I_o = N_o /10 = -216$ dBW/Hz (-126 dBm/MHz) used in simulations

2. Short-term, < 0.0X% of time I_0/N_0 can be exceeded – discuss X with example

3. Long term, TT&C earth stations: – I_0/N_0 = -20dB ($\Delta T/T$ = 1%) addressed by CBA; this special case is not considered in these simulations

Simulation method[1] and assumptions

- Move interfering station in all directions around the earth station while pointing interferer at full OOBE power at earth station, to compute minimum distance needed
- Compute the I_0/N_0 =10% in the victim downlink – output the contours to Google Earth for visualization
- Propagation Models and the reason for application:
  - Terrestrial ITU-R P.452-16 covers basic path loss, LOS, multipath, focusing, diffraction and height/gain clutter loss
  - Clutter Loss ITU P. 2108 clutter at the ends of the link
  - ITU-R P.525 Basic Free space propagation loss
- Victim antenna gain pattern:
  - ITU S.580-6 earth station sidelobes
- Terrain
  - Smooth earth
  - Local buildings/structures, vegetation, etc – not available/not be applied

1. Using VisualysePRO – www.transfinite.co.uk.

UCSD Earth Station

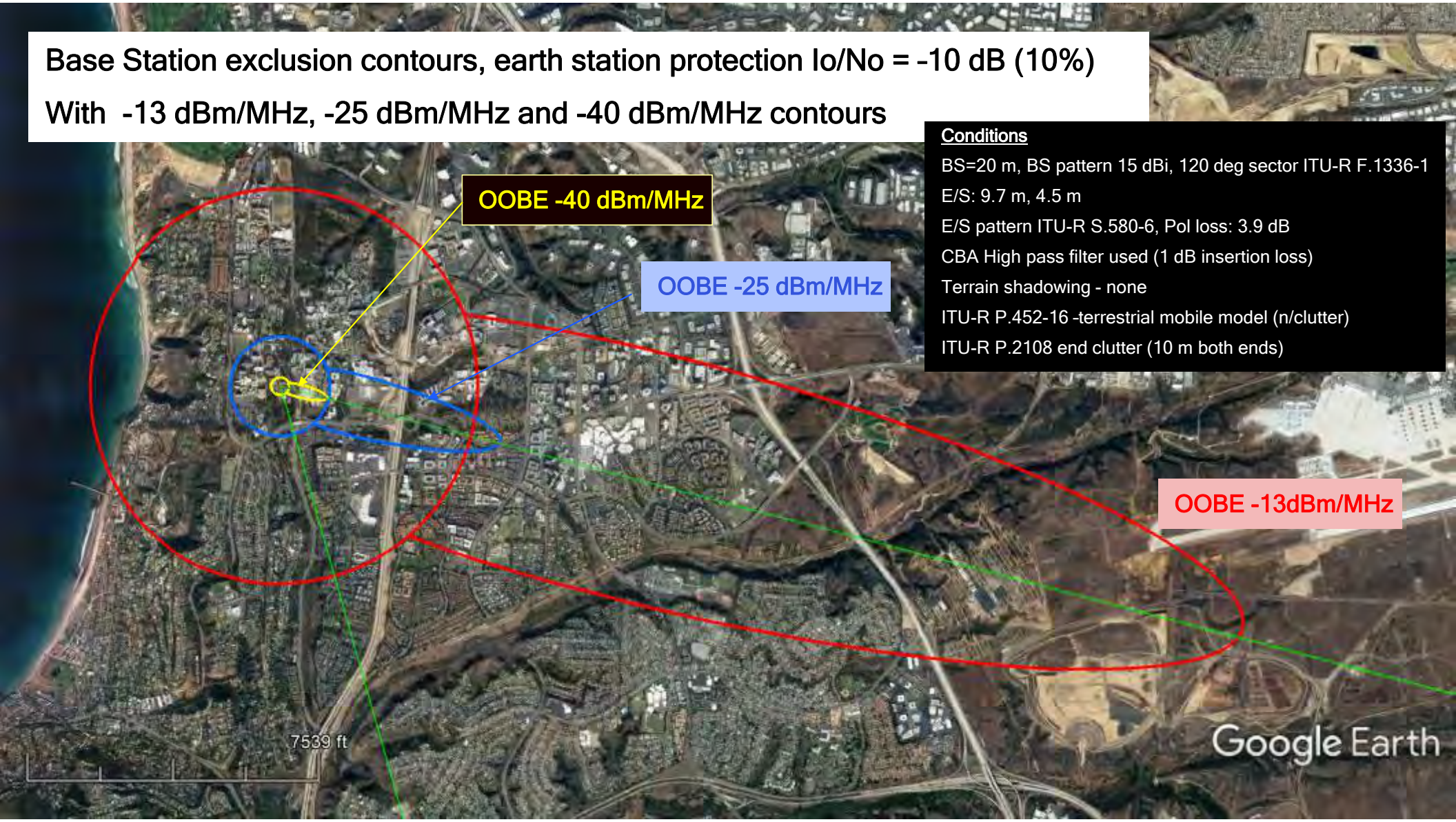
Practical exclusion zone examples

UE and Base Station (BS)

Adjacent channel interference ΔF >20MHz

Base Station exclusion contours, earth station protection Io/No = -10 dB (10%)

With -13 dBm/MHz, -25 dBm/MHz and -40 dBm/MHz contours



Conditions

BS=20 m, BS pattern 15 dBi, 120 deg sector ITU-R F.1336-1

E/S: 9.7 m, 4.5 m

E/S pattern ITU-R S.580-6, Pol loss: 3.9 dB

CBA High pass filter used (1 dB insertion loss)

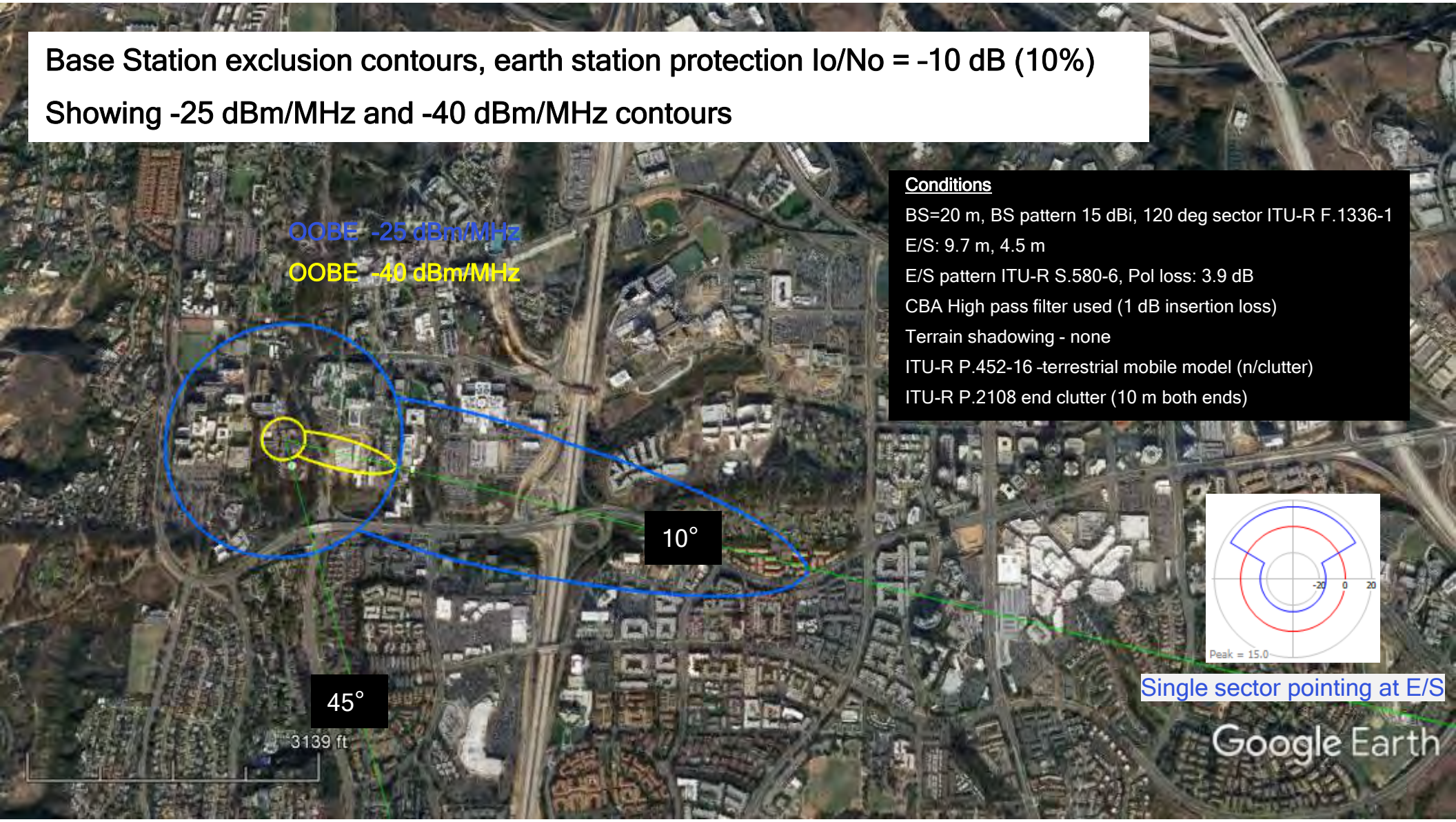
Terrain shadowing - none

ITU-R P.452-16 -terrestrial mobile model (n/clutter)

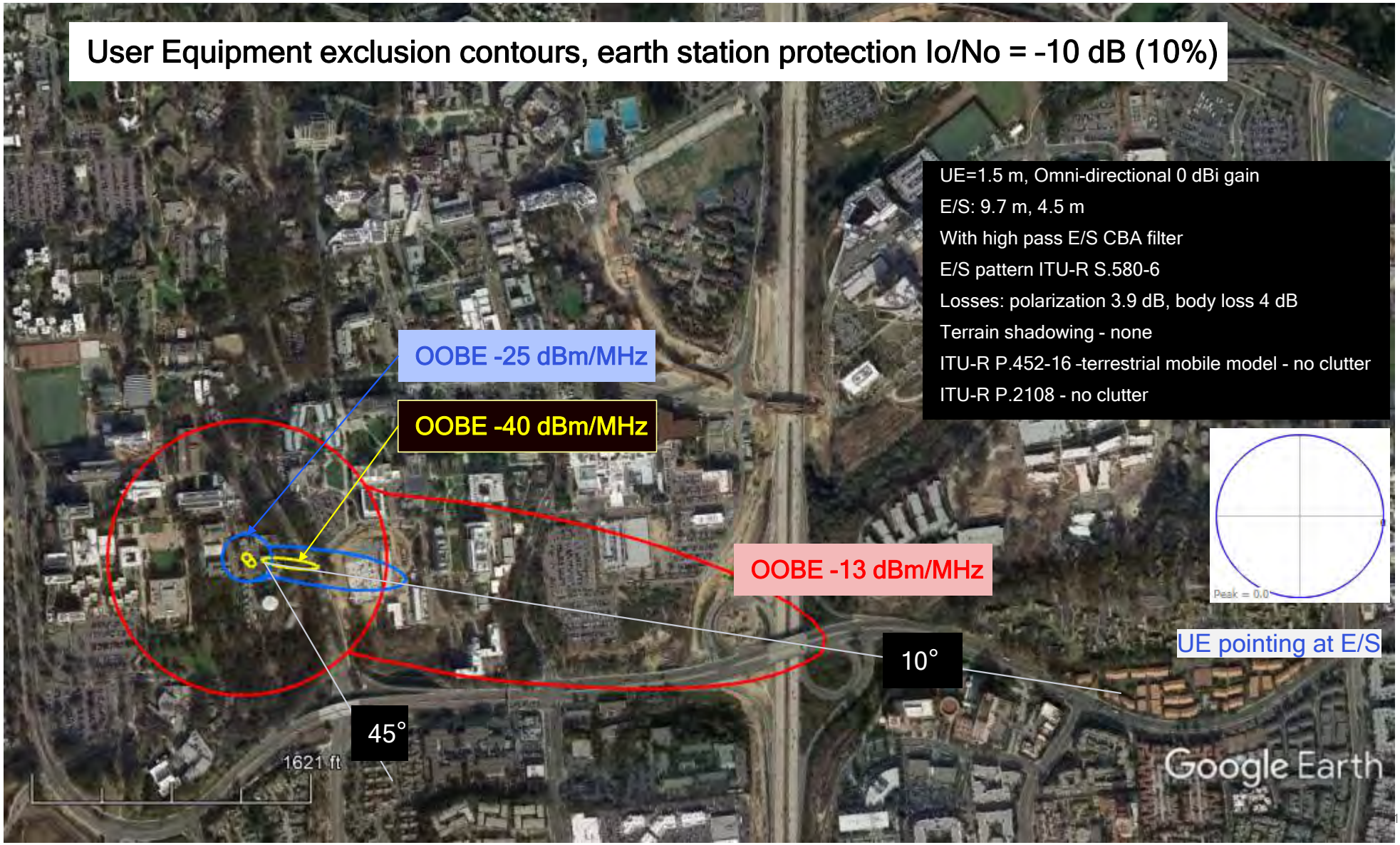
ITU-R P.2108 end clutter (10 m both ends)

Base Station exclusion contours, earth station protection Io/No = -10 dB (10%)

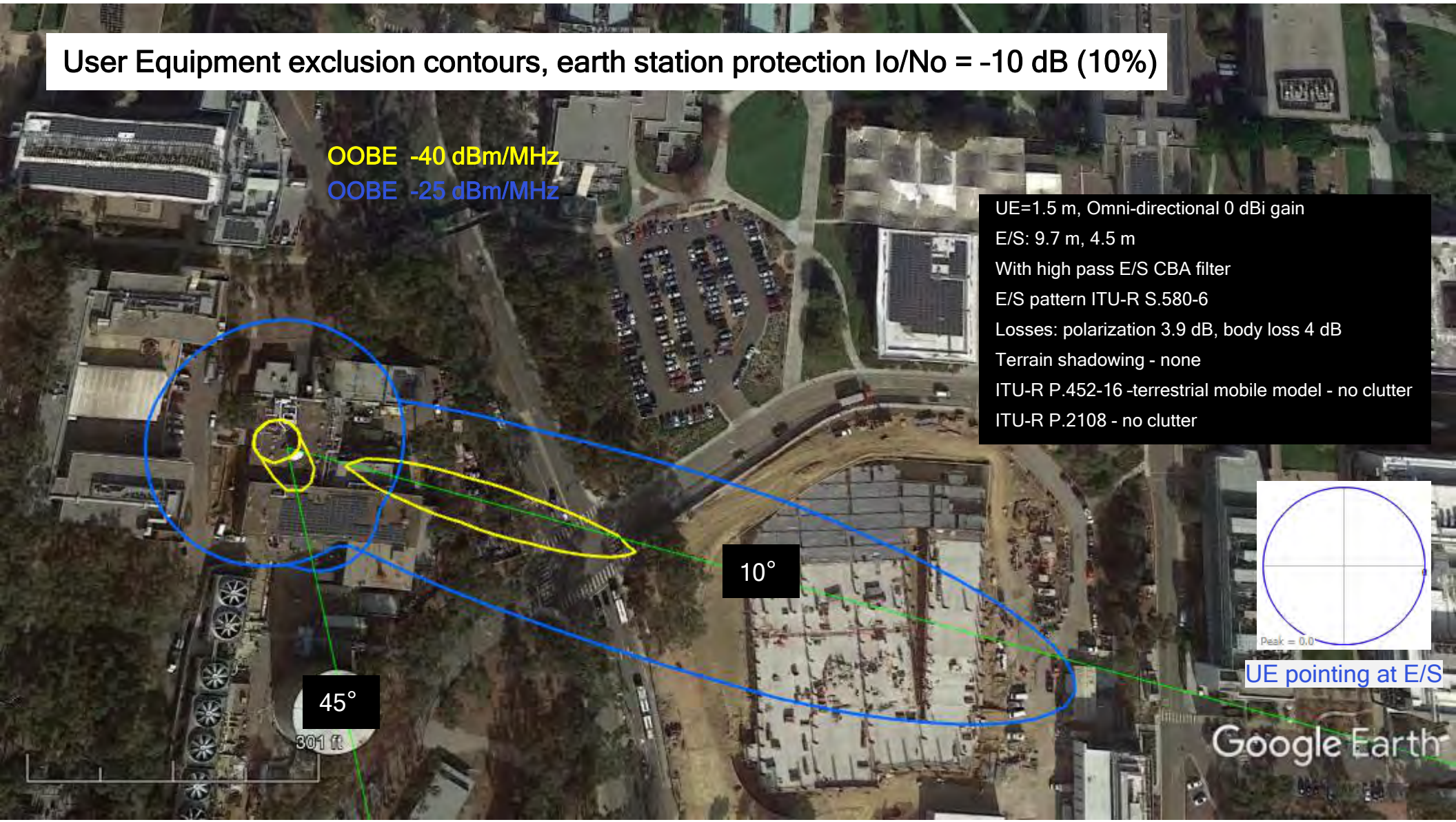
Showing -25 dBm/MHz and -40 dBm/MHz contours



User Equipment exclusion contours, earth station protection Io/No = -10 dB (10%)



User Equipment exclusion contours, earth station protection Io/No = -10 dB (10%)

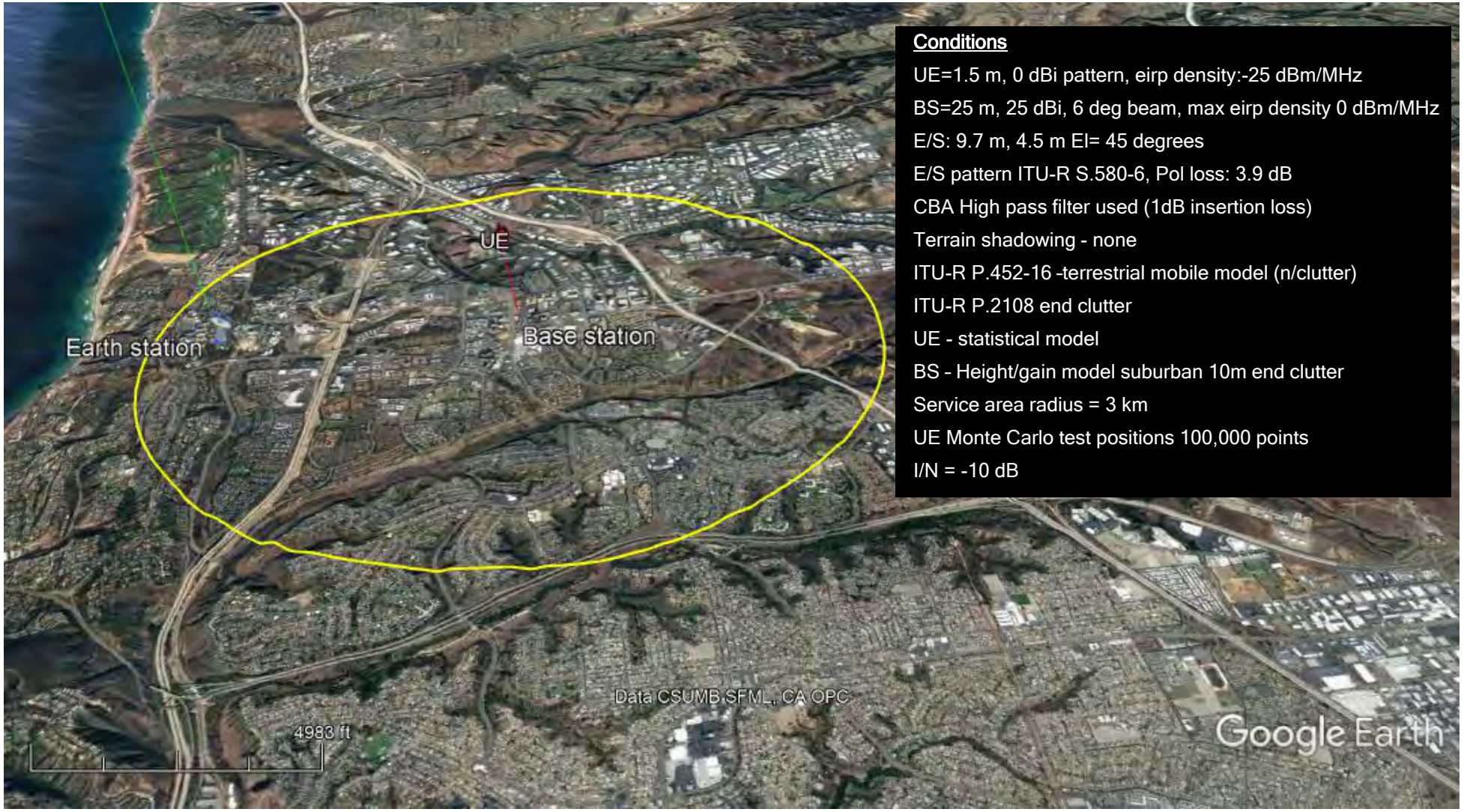


UCSD Earth Station

Likelihood of UE and BS exceeding I/N threshold

Simplified example for illustration

Illustrative scenario for BS and UE I/N statistics



Conditions

UE=1.5 m, 0 dBi pattern, eirp density:-25 dBm/MHz

BS=25 m, 25 dBi, 6 deg beam, max eirp density 0 dBm/MHz

E/S: 9.7 m, 4.5 m El= 45 degrees

E/S pattern ITU-R S.580-6, Pol loss: 3.9 dB

CBA High pass filter used (1dB insertion loss)

Terrain shadowing - none

ITU-R P.452-16 -terrestrial mobile model (n/clutter)

ITU-R P.2108 end clutter

UE - statistical model

BS - Height/gain model suburban 10m end clutter

Service area radius = 3 km

UE Monte Carlo test positions 100,000 points

I/N = -10 dB

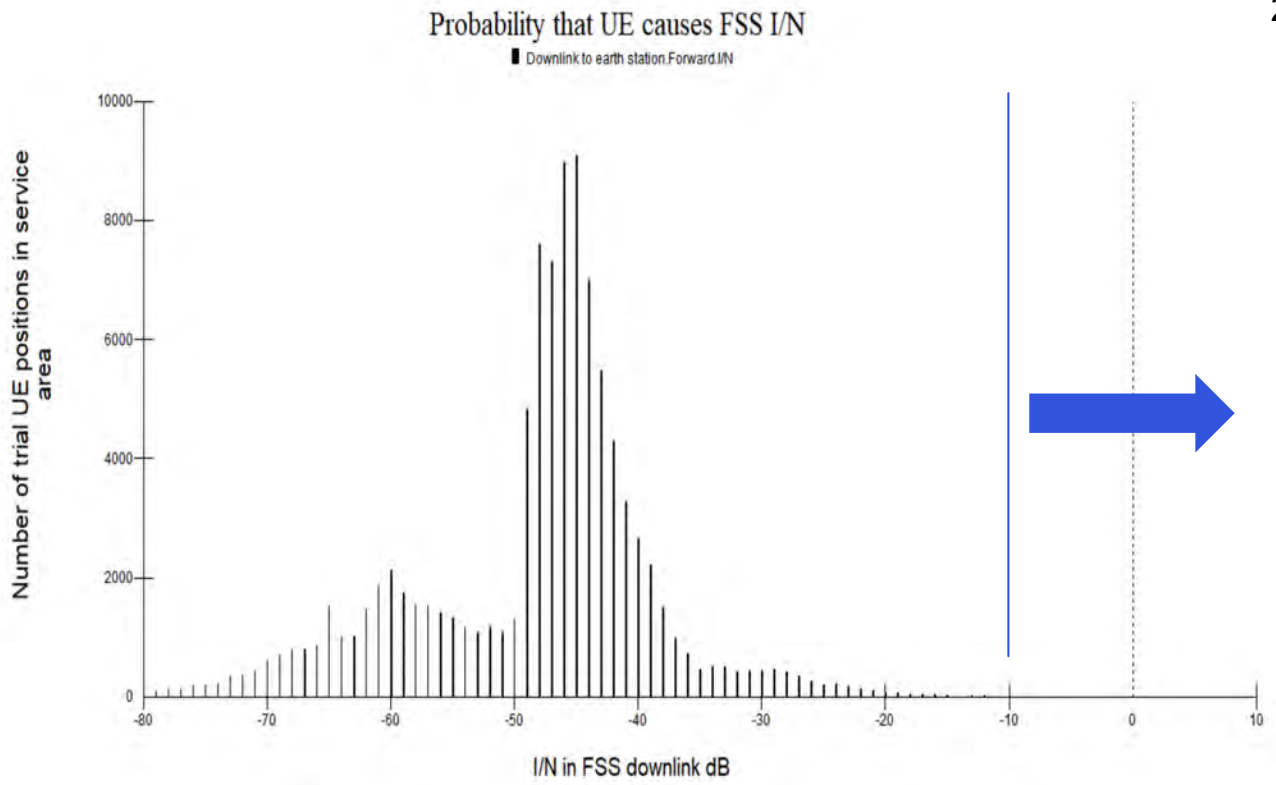
Probability that a specified I/N occurs due to UE location (OOBE @ -25 dBm/MHz)

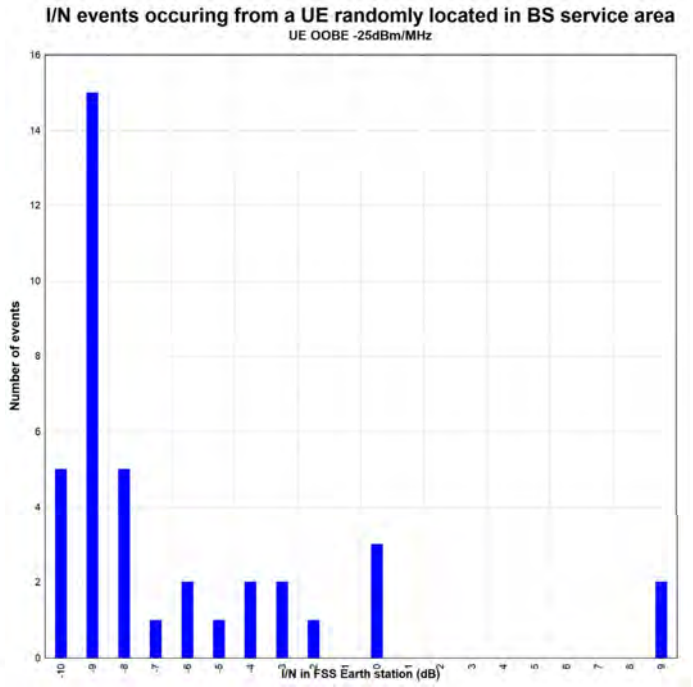
Number of events that:

I/N > -10 dB 39 events in 100,000 = 0.039%

I/N > 0 dB 2 events in 100,000 =0.002%

2 worst case I/N events at UE at the feed





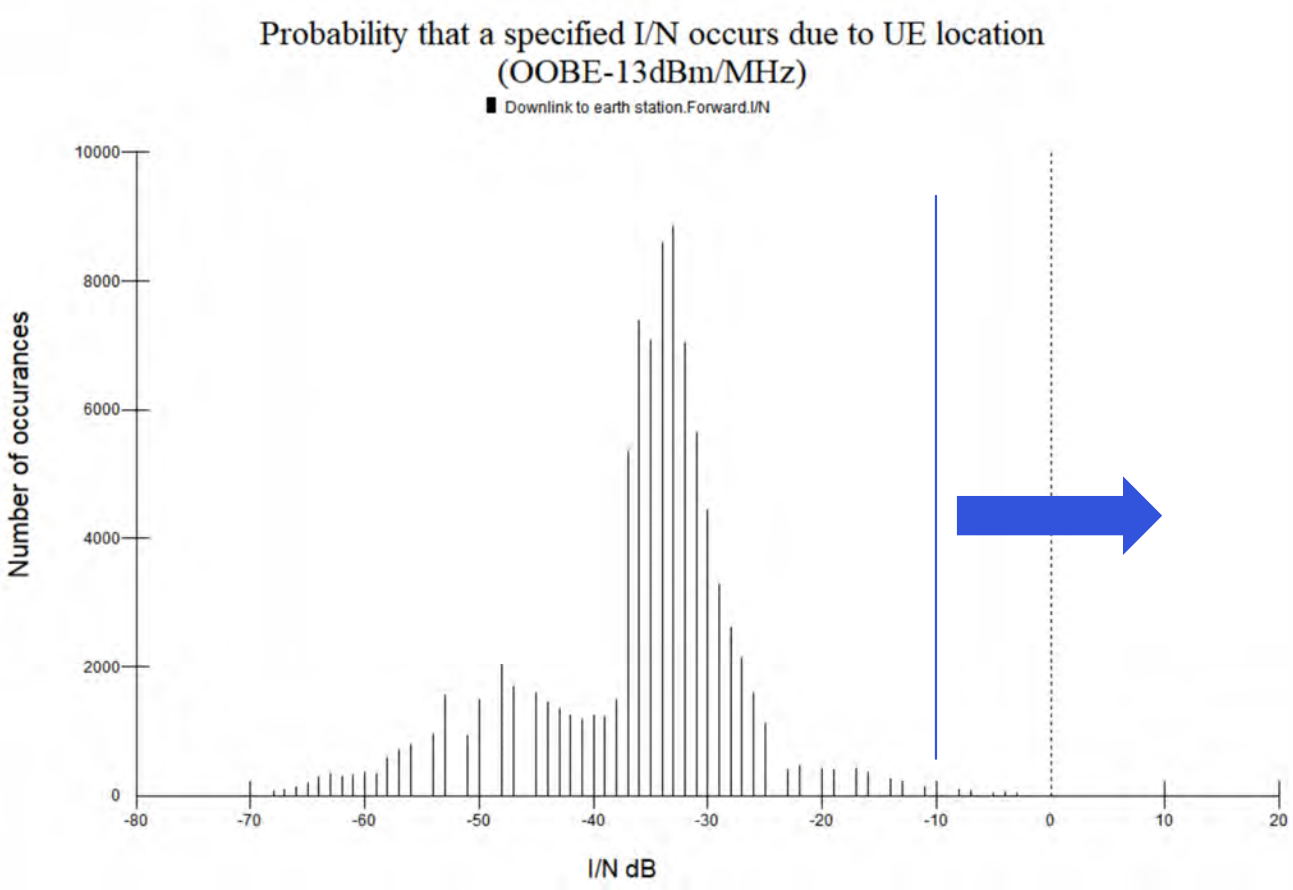
Probability that a specified I/N occurs due to UE location (OOBE -13dBm/MHz)

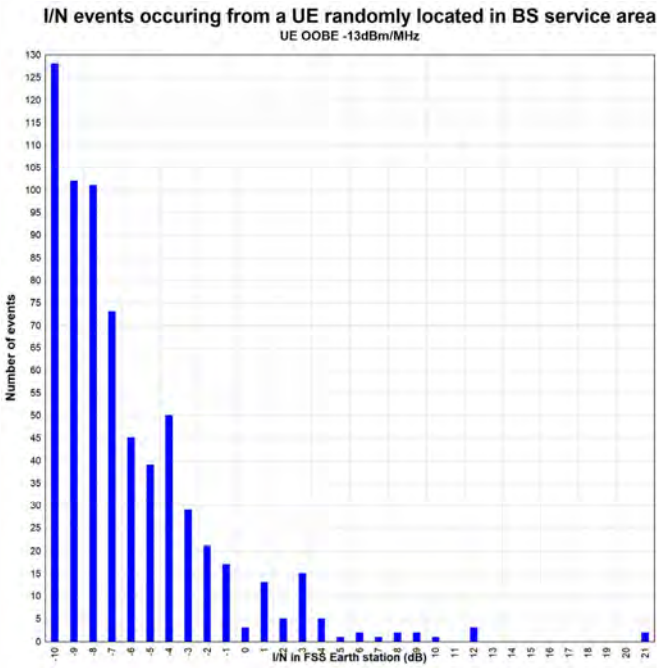
Number of events that:

I/N > -10 dB 660 events in 100,000 = 0.66%

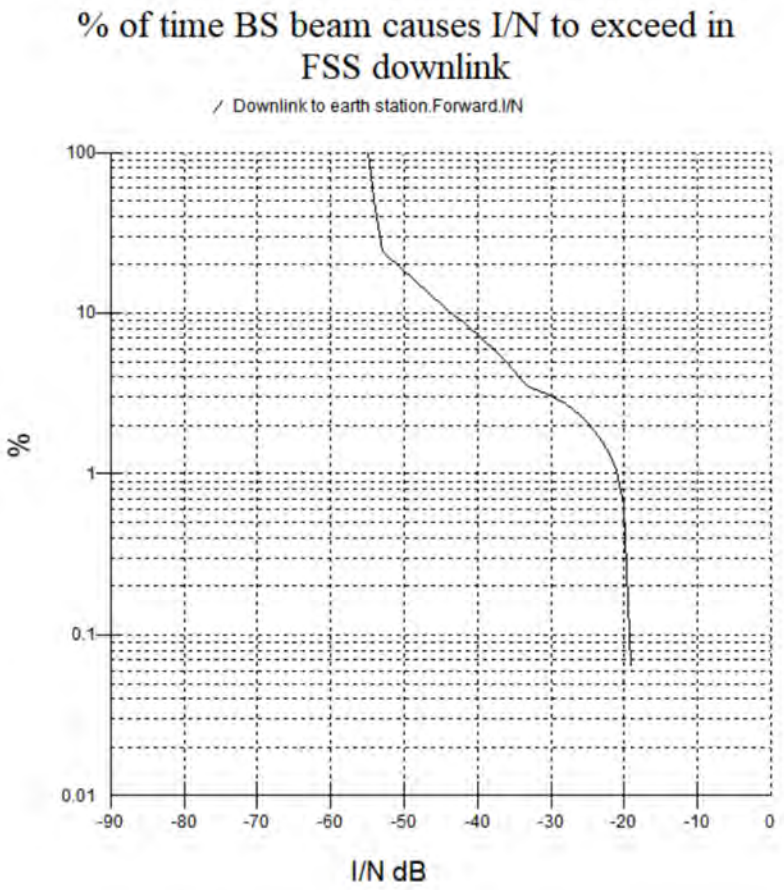
I/N > 0 dB 52 events in 100,000 =0.052%

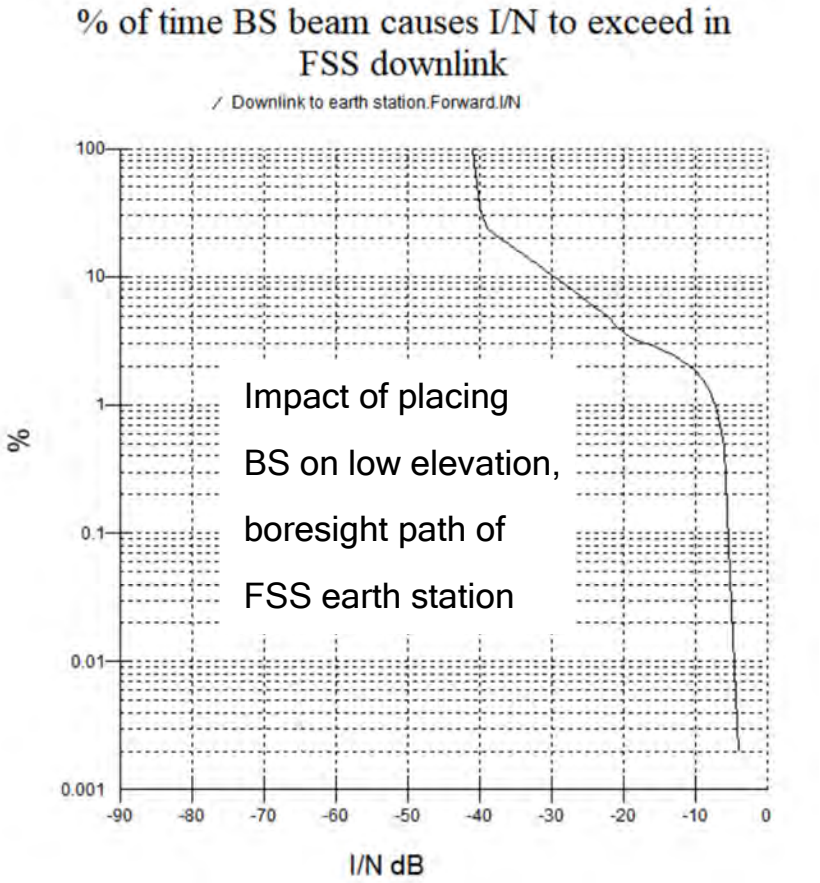
39 I/N events > 2dB occur at reflector or near feed





Base Station I/N impact from MIMO 25 dBi/6 degree beam using example locations shown





Backoff to Meet CBRS mask and Mid-Range mask

- Summary for CBRS band emission limits (40MHz channel BW at RF band edge)
  - Worst case 11.5 dB back-off for full and low resource allocation for 40 MHz channel at the upper edge of the band
  - Backoff is roughly half that amount for 20 MHz channel at upper edge of band

CBRS Proposed Limits Power Back-off, dB				
Channel Bandwidth	Full Allocation		Low LCRB	
	DFT-s-OFDM	CP-OFDM	DFT-s-OFDM	CP-OFDM
40M edge	10	11.5	10	11.5
20M edge	4.5	6	4.5	6

- Summary for mid-range OOBE mask band (40MHz channel BW at RF band edge)
  - Worst case 5.5 dB back-off for full and for low resource allocation for 40 MHz channel at the upper edge of the band
  - No additional backoff beyond what is needed to comply with the 3GPP specification for 20 MHz channel at the upper edge or for a 40 MHz channel offset 20 MHz from edge

Compromise Limits Power Back-off, dB					
Channel Bandwidth	Full Allocation		Low LCRB		Notes
	DFT-s-OFDM	CP-OFDM	DFT-s-OFDM	CP-OFDM	
40M edge	4	5.5	4	5.5	PC3 NS_04 type back-off; QPSK
40M (20M offset from edge)	MPR	MPR	MPR	MPR	3GPP specification
20M edge	MPR	MPR	MPR	MPR	3GPP specification

Conclusions and Proposed Path Forward

- Mask of -13 dBm/MHz and -25 dBm/MHz allows for much less UE power back-off for the uppermost mobile channel (than current CBRS limits require) and substantially improves BS service area, ensuring robust 5G service
  - BS site coordination can protect FSS earth stations
  - Very small likelihood UE will be inside earth station contour and operate in manner that causes harmful interference; in unlikely event of harmful interference, a “hot-line” can be provided for quick remediation
- Preferred option is for FCC to permit network signaling to require UE to follow this mask when communicating with a base station within 1 km of an FSS receiver and to follow the less restrictive -13 dBm/MHz level in all other areas, providing even more robust 5G service on the spectrum nationwide

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